



Standard Test Method for Vickers Hardness of Metallic Materials¹

This standard is issued under the fixed designation E 92; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the determination of the Vickers hardness of metallic materials, using applied forces of 1 kgf to 120 kgf,² the verification of Vickers hardness testing machines (Part B), and the calibration of standardized hardness test blocks (Part C). Two general classes of standard tests are recognized:

1.1.1 *Verification, Laboratory, or Referee Tests*, where a high degree of accuracy is required.

1.1.2 *Routine Tests*, where a somewhat lower degree of accuracy is permissible.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

E 4 Practices for Force Verification of Testing Machines³

E 140 Hardness Conversion Tables for Metals (Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Rockwell Superficial Hardness, Knoop Hard-

ness, and Scleroscope Hardness)³

E 384 Test Method for Microindentation Hardness of Materials³

3. Terminology

3.1 *calibration*—determination of the values of the significant parameters by comparison with values indicated by a reference instrument or by a set of reference standards.

3.2 *verification*—checking or testing to assure conformance with the specification.

3.3 *Vickers hardness number, HV*—a number related to the applied force and the surface area of the permanent impression made by a square-based pyramidal diamond indenter having included face angles of 136° (see Fig. 1 and Table 1), computed from the equation:

$$HV = 2P \sin(\alpha/2)/d^2 = 1.8544P/d^2 \quad (1)$$

where:

P = force, kgf,

d = mean diagonal of impression, mm, and

α = face angle of diamond = 136°.

3.4 *Vickers hardness test*—an indentation hardness test using calibrated machines to force a square-based pyramidal diamond indenter having specified face angles, under a predetermined force, into the surface of the material under test and to measure the diagonals of the resulting impression after removal of the force.

3.4.1 Vickers hardness tests are made at test forces of 1 kgf to 120 kgf.

3.4.2 For practical purposes the Vickers hardness number is constant when a square-based diamond pyramid with a face angle of 136° is used with applied forces of 5 kgf and higher.

¹ This test method is under the jurisdiction of ASTM Committee E28 on Mechanical Testing and is the direct responsibility of Subcommittee E28.06 on Indentation Hardness Testing.

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² A procedure covering Vickers tests using applied forces of 1 gf to 1000 gf (1 kgf) may be found in Test Method E 384, Test Method for Microindentation Hardness of Materials, appearing in the *Annual Book of ASTM Standards*, Vol 03.01.

³ *Annual Book of ASTM Standards*, Vol 03.01.

ASTM E 92 – 82 (2003)

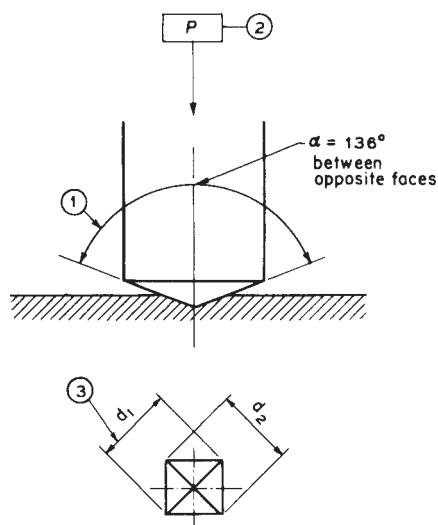


FIG. 1 Vickers Hardness Test (see Table 1)

TABLE 1 Symbols and Designations Associated with Fig. 1

Number	Symbol	Designation
1	...	Angle at the vertex of the pyramidal indenter (136°)
2	<i>P</i>	Test force in kilograms-force
3	<i>d</i>	Arithmetic mean of the two diagonals <i>d</i> ¹ and <i>d</i> ²

TABLE 2 Vickers Hardness Numbers
(Diamond, 136° Face Angle, force of 1 kgf)

Diagonal of Impression, mm	Vickers Hardness Number for Diagonal Measured to 0.0001 mm									
	0.0000	0.0001	0.0002	0.0003	0.0004	0.0005	0.0006	0.0007	0.0008	0.0009
0.005	74 170	71 290	68 580	66 020	63 590	61 300	59 130	57 080	55 120	53 270
0.006	51 510	49 840	48 240	46 720	45 270	43 890	42 570	41 310	40 100	38 950
0.007	37 840	36 790	35 770	34 800	33 860	32 970	32 100	31 280	30 480	29 710
0.008	28 970	28 260	27 580	26 920	26 280	25 670	25 070	24 500	23 950	23 410
0.009	22 890	22 390	21 910	21 440	20 990	20 550	20 120	19 710	19 310	18 920
0.010	18 540	18 180	17 820	17 480	17 140	16 820	16 500	16 200	15 900	15 610
0.011	15 330	15 050	14 780	14 520	14 270	14 020	13 780	13 550	13 320	13 090
0.012	12 880	12 670	12 460	12 260	12 060	11 870	11 680	11 500	11 320	11 140
0.013	10 970	10 810	10 640	10 480	10 330	10 170	10 030	9 880	9 737	9 598
0.014	9 461	9 327	9 196	9 068	8 943	8 820	8 699	8 581	8 466	8 353
0.015	8 242	8 133	8 026	7 922	7 819	7 718	7 620	7 523	7 428	7 335
0.016	7 244	7 154	7 066	6 979	6 895	6 811	6 729	6 649	6 570	6 493
0.017	6 416	6 342	6 268	6 196	6 125	6 055	5 986	5 919	5 853	5 787
0.018	5 723	5 660	5 598	5 537	5 477	5 418	5 360	5 303	5 247	5 191
0.019	5 137	5 083	5 030	4 978	4 927	4 877	4 827	4 778	4 730	4 683
0.020	4 636	4 590	4 545	4 500	4 456	4 413	4 370	4 328	4 286	4 245
0.021	4 205	4 165	4 126	4 087	4 049	4 012	3 975	3 938	3 902	3 866
0.022	3 831	3 797	3 763	3 729	3 696	3 663	3 631	3 599	3 567	3 536
0.023	3 505	3 475	3 445	3 416	3 387	3 358	3 329	3 301	3 274	3 246
0.024	3 219	3 193	3 166	3 140	3 115	3 089	3 064	3 039	3 015	2 991
0.025	2 967	2 943	2 920	2 897	2 874	2 852	2 830	2 808	2 786	2 764
0.026	2 743	2 722	2 701	2 681	2 661	2 641	2 621	2 601	2 582	2 563
0.027	2 544	2 525	2 506	2 488	2 470	2 452	2 434	2 417	2 399	2 382
0.028	2 365	2 348	2 332	2 315	2 299	2 283	2 267	2 251	2 236	2 220
0.029	2 205	2 190	2 175	2 160	2 145	2 131	2 116	2 102	2 088	2 074
0.030	2 060	2 047	2 033	2 020	2 007	1 993	1 980	1 968	1 955	1 942
0.031	1 930	1 917	1 905	1 893	1 881	1 869	1 857	1 845	1 834	1 822
0.032	1 811	1 800	1 788	1 777	1 766	1 756	1 745	1 734	1 724	1 713
0.033	1 703	1 693	1 682	1 672	1 662	1 652	1 643	1 633	1 623	1 614


 **E 92 – 82 (2003)**

TABLE 2 *Continued*

Diagonal of Impression, mm	Vickers Hardness Number for Diagonal Measured to 0.0001 mm									
	0.0000	0.0001	0.0002	0.0003	0.0004	0.0005	0.0006	0.0007	0.0008	0.0009
0.034	1 604	1 595	1 585	1 576	1 567	1 558	1 549	1 540	1 531	1 522
0.035	1 514	1 505	1 497	1 488	1 480	1 471	1 463	1 455	1 447	1 439
0.036	1 431	1 423	1 415	1 407	1 400	1 392	1 384	1 377	1 369	1 362
0.037	1 355	1 347	1 340	1 333	1 326	1 319	1 312	1 305	1 298	1 291
0.038	1 284	1 277	1 271	1 264	1 258	1 251	1 245	1 238	1 232	1 225
0.039	1 219	1 213	1 207	1 201	1 195	1 189	1 183	1 177	1 171	1 165
0.040	1 159	1 153	1 147	1 142	1 136	1 131	1 125	1 119	1 114	1 109
0.041	1 103	1 098	1 092	1 087	1 082	1 077	1 072	1 066	1 061	1 056
0.042	1 051	1 046	1 041	1 036	1 031	1 027	1 022	1 017	1 012	1 008
0.043	1 003	998	994	989	985	980	975	971	967	962
0.044	958	953	949	945	941	936	932	928	924	920
0.045	916	912	908	904	900	896	892	888	884	880
0.046	876	873	869	865	861	858	854	850	847	843
0.047	839	836	832	829	825	822	818	815	812	808
0.048	805	802	798	795	792	788	785	782	779	775
0.049	772	769	766	763	760	757	754	751	748	745
0.050	742	739	736	733	730	727	724	721	719	716
0.051	713	710	707	705	702	699	696	694	691	688
0.052	686	683	681	678	675	673	670	668	665	663
0.053	660	658	655	653	650	648	645	643	641	638
0.054	636	634	631	629	627	624	622	620	617	615
0.055	613	611	609	606	604	602	600	598	596	593
0.056	591	589	587	585	583	581	579	577	575	573
0.057	571	569	567	565	563	561	559	557	555	553
0.058	551	549	547	546	544	542	540	538	536	535
0.059	533	531	529	527	526	524	522	520	519	516.8
0.060	515.1	513.4	511.7	510.0	508.3	506.6	505.0	503.3	501.6	500.0
0.061	498.4	496.7	495.1	493.5	491.9	490.3	488.7	487.1	485.5	484.0
0.062	482.4	480.9	479.3	477.8	476.2	474.7	473.2	471.7	470.2	468.7
0.063	467.2	465.7	464.3	462.8	461.3	459.9	458.4	457.0	455.6	454.1
0.064	452.7	451.3	449.9	448.5	447.1	445.7	444.4	443.0	441.6	440.3
0.065	438.9	437.6	436.2	434.9	433.6	432.2	430.9	429.6	428.3	427.0
0.066	425.7	424.4	423.1	421.9	420.6	419.3	418.1	416.8	415.6	414.3
0.067	413.1	411.9	410.6	409.4	408.2	407.0	405.8	404.6	403.4	402.2
0.068	401.0	399.9	398.7	397.5	396.3	395.2	394.0	392.9	391.8	390.6
0.069	389.5	388.4	387.2	386.1	385.0	383.9	382.8	381.7	380.6	379.5
0.070	378.4	377.4	376.3	375.2	374.2	373.1	372.0	371.0	369.9	368.9
0.071	367.9	366.8	365.8	364.8	363.7	362.7	361.7	360.7	359.7	358.7
0.072	357.7	356.7	355.7	354.7	353.8	352.8	351.8	350.9	349.9	348.9
0.073	348.0	347.0	346.1	345.1	344.2	343.3	342.3	341.4	340.5	339.6
0.074	338.6	337.7	336.8	335.9	335.0	334.1	333.2	332.3	331.4	330.5
0.075	329.7	328.8	327.9	327.0	326.2	325.3	324.5	323.6	322.7	321.9
0.076	321.0	320.2	319.4	318.5	317.7	316.9	316.0	315.2	314.4	313.6
0.077	312.8	312.0	311.1	310.3	309.5	308.7	307.9	307.2	306.4	305.6
0.078	304.8	304.0	303.2	302.5	301.7	300.9	300.2	299.4	298.6	297.9
0.079	297.1	296.4	295.6	294.9	294.1	293.4	292.7	291.9	291.2	290.5
0.080	289.7	289.0	288.3	287.6	286.9	286.2	285.4	284.7	284.0	283.3
0.081	282.6	281.9	281.2	280.6	279.9	279.2	278.5	277.8	277.1	276.5
0.082	275.8	275.1	274.4	273.8	273.1	272.4	271.8	271.1	270.5	269.8
0.083	269.2	268.5	267.9	267.2	266.6	266.0	265.3	264.7	264.1	263.4
0.084	262.8	262.2	261.6	260.9	260.3	259.7	259.1	258.5	257.9	257.3
0.085	256.7	256.1	255.5	254.9	254.3	253.7	253.1	252.5	251.9	251.3
0.086	250.7	250.1	249.6	249.0	248.4	247.8	247.3	246.7	246.1	245.6
0.087	245.0	244.4	243.9	243.3	242.8	242.2	241.6	241.1	240.6	240.0
0.088	239.5	238.9	238.4	237.8	237.3	236.8	236.2	235.7	235.2	234.6
0.089	234.1	233.6	233.1	232.5	232.0	231.5	231.0	230.5	230.0	229.4
0.090	228.9	228.4	227.9	227.4	226.9	226.4	225.9	225.4	224.9	224.4
0.091	223.9	223.4	222.9	222.5	222.0	221.5	221.0	220.5	220.0	219.6
0.092	219.1	218.6	218.1	217.7	217.1	216.7	216.3	215.8	215.3	214.9
0.093	214.4	213.9	213.5	213.0	212.6	212.1	211.7	211.2	210.8	210.3

TABLE 2 Continued

Diagonal of Impression, mm	Vickers Hardness Number for Diagonal Measured to 0.0001 mm									
	0.0000	0.0001	0.0002	0.0003	0.0004	0.0005	0.0006	0.0007	0.0008	0.0009
0.094	209.9	209.4	209.0	208.5	208.1	207.6	207.2	206.8	206.3	205.9
0.095	205.5	205.0	204.6	204.2	203.8	203.3	202.9	202.5	202.1	201.6
0.096	201.2	200.8	200.4	200.0	199.5	199.1	198.7	198.3	197.9	197.5
0.097	197.1	196.7	196.3	195.9	195.5	195.1	194.7	194.3	193.9	193.5
0.098	193.1	192.7	192.3	191.9	191.5	191.1	190.7	190.4	190.0	189.6
0.099	189.2	188.8	188.4	188.1	187.7	187.3	186.9	186.6	186.2	185.9

At lower test forces the Vickers hardness may be force-dependent. In Table 2 are given the Vickers hardness numbers for a test force of 1 kgf. For obtaining hardness numbers when other test forces are used, the Vickers hardness number obtained from Table 2 is multiplied by the test force in kilograms-force (Table 3).

NOTE 1—The Vickers hardness number is followed by the symbol HV

TABLE 3 Decimal Point Finder for Use with Table 2

An example of determination of hardness numbers follows the table.

Diagonal Length, mm	Vickers Hardness (HV), 1-kgf Force
0.005	74 200
0.006	51 500
0.007	37 800
0.008	29 000
0.009	22 900
0.010	18 540
0.020	4 640
0.030	2 060
0.040	1 159
0.050	742
0.060	515
0.070	378
0.080	290
0.090	229
0.100	185.4
0.200	46.4
0.300	20.6
0.400	11.6
0.500	7.42
0.600	5.15
0.700	3.78
0.800	2.90
0.900	2.29
1.000	1.85
1.100	1.53
1.200	1.29
1.300	1.10
1.400	0.946
1.500	0.824
1.600	0.724
1.700	0.642
1.800	0.572
1.900	0.514
2.000	0.464

Example—Using a 50-kgf test force, the average measured diagonal length = 0.644 mm.

In Table 2 read:

HV = 447 at 0.0644-mm diagonal length at 1-kgf force.

Using Table 3 determine:

HV = 4.47 at 0.644-mm diagonal length at 1-kgf force.

$50 \times 4.47 = 224$ HV for 50-kg test force.

with a suffix number denoting the force and second suffix number indicating the duration of forcing when the latter differs from 10 to 15 s, which is the normal force time. *Example:*

440 HV 30 = Vickers hardness of 440 measured under a force of 30 kgf applied for 10 to 15 s.

440 HV 30/20 = Vickers hardness of 440 measured under a force of 30 kgf applied for 20 s.

A. GENERAL DESCRIPTION AND TEST PROCEDURE FOR VICKERS HARDNESS TESTS

4. Apparatus

4.1 *Testing Machine*—Equipment for Vickers hardness testing usually consists of a testing machine which supports the specimen and permits the indenter and the specimen to be brought into contact gradually and smoothly under a predetermined force, which is applied for a fixed period of time. The design of the machine should be such that no rocking or lateral movement of the indenter or specimen is permitted while the force is being applied or removed. A measuring microscope is usually mounted on the machine in such a manner that the impression in the specimen may be readily located in the optical field.

4.2 Indenter:

4.2.1 The indenter shall be a highly polished, pointed, square-based pyramidal diamond with face angles of $136^\circ \pm 30$ min.

4.2.2 All four faces of the indenter shall be equally inclined to the axis of the indenter (within ± 30 min) and meet at a sharp point, that is, the line of junction between opposite faces shall not be more than 0.001 mm in length as shown in Fig. 2.

4.2.3 The diamond should be examined periodically and if it is loose in the mounting material, chipped, or cracked, it should be discarded or reconditioned.

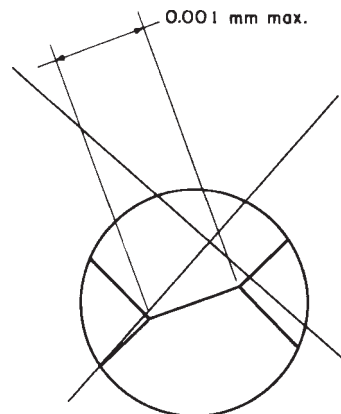


FIG. 2 Junction of Indenter Faces